Collective expansion and $\pi^{\pm} - K^{\pm}$ correlation analysis at RHIC

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Collective expansion is one of the most important feature that is expected to take place in the Au-Au collision at RHIC energy. Indeed, particles created in the collisions between the incoming partons are expected to re-interact with one another, hence pushing each other towards the vacuum outside of the collision zone. What are the degrees of freedom associated with this collective expansion, partonic, hadronic or both? In order to gain insights about the collective expansion, we attempt to describe the final state of the system relying on the blast wave parameterization [1]. The aim of this analysis is to show that collective transverse expansion ties together transverse momentum spectra, elliptic flow and particle source size. The good quality of the fit, shown in table 1, shows that π, K, p, Λ transverse mass spectra, π, p elliptic flow, and π source radii can be consistently described within a framework whose main feature is the collective expansion. The temperature (T) and average flow transverse velocity $\langle\beta_T\rangle$ are mostly constrained by transverse mass spectra. The large value of $\langle\beta_T\rangle$ shows that transverse flow is large at RHIC. The flow azimuthal modulation (ρ_a) and the ratio of the in-plane radius over the out-of-plane radius (R_x/R_y) are constrained by elliptic flow. The absolute value of the radius (R_x or R_y) and the system proper life time (τ) and the emission duration (Δt) are constrained by pion source radii. These fits yield surprisingly short lifetimes (τ < 10 fm/c), which cannot be obtained by any hydrodynamical model.

Furthermore, the analysis of the correlation between non-identical particles may be used to probe the collective expansion. Indeed, the Coulomb interaction between charged pions and kaons introduce a correlation between $\pi^{\pm} - K^{\pm}$ pairs that can be used to study whether or not π and K are emitted on average at the same space-time point. Pions and kaons reconstructed and identified with the STAR TPC have been used to construct pion-kaon correlation functions [6]. The experimental correlation function are fitted by assuming that the separation between pions and kaons in the $\pi - K$ pair rest frame can be described by a Gaussian. The σ of the fit function measures the dispersion of the pion and kaon sources while the mean (μ) measures the average separation between pions and kaons. The fit results are summarized in table 2. μ is significantly different from zero showing that pions and kaons are not emitted at the same average space-time position. This shift is reproduced qualitatively by the blast wave parameterization, due to the interplay between collective transverse expansion and random motion. On the other hand, the blast wave parameterization under-estimates the source width (σ), which may be explained recalling that it does not include any resonances such as ω or ϕ that increase the width of pions and kaons sources, respectively.

Thus, transverse expansion consistently explains π, K, p, Λ transverse mass spectra, π, p elliptic flow, π source size and the average space-time separation between pions and kaons . The contribution from resonance feeddown remains to be carefully investigated.

	Central	Mid-central	Peripheral
π, K, p spectra [2]	0-5%	15-30%	60-92%
Λ spectra [3]	0-5%	20-35%	35-75%
pion radii [4]	0-12%	12-32%	32-72%
Elliptic flow [5]	0-11%	11-45%	45-85%
T (MeV)	108 ± 3	106 ± 3	95 ± 4
$\langle\beta_T\rangle$ (c)	0.53 ± 0.01	0.52 ± 0.02	0.47 ± 0.02
ρ_a	0.059 ± 0.008	0.052 ± 0.006	0.04 ± 0.01
$R_x(fm)$	12.9 ± 0.3	10.2 ± 0.5	8.00 ± 0.4
$R_y(fm)$	12.8 ± 0.3	11.8 ± 0.6	10.1 ± 0.4
$\tau(fm/c)$	8.9 ± 0.3	7.4 ± 1.2	6.5 ± 0.8
$\Delta t(fm/c)$	0.002 ± 1.4	0.8 ± 3.2	0.8 ± 1.9
χ^2/dof	80.5/93	153.7/84	74.3/60

TABLE I: Blast wave fit of published data in Au-Au collision at $\sqrt{s_{NN}}$ =130 GeV

	σ (fm)	μ (fm)	χ^2 / dof
Data	$12.5 \pm 0.4^{+2.2}_{-3}$	$-5.6 \pm 0.6^{+1.9}_{-1.3}$	134.5/110
Blast Wave	9.9 ± 0.1	-6.9 ± 0.3	-

TABLE II: Spatial separation between pions and kaons in the $\pi - K$ pair rest frame in Au-Au collision at $\sqrt{s_{NN}}$ =130 GeV. Statistic and systematic (data only) errors are included.

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